# 3 ENVIRONMENTAL SETTING

This chapter describes the environmental setting of Maryland streams. Similar to other states in the mid-Atlantic region, Maryland stream environments vary considerably from east to west and from north to south. Within the chapter, important features such as geologic history, climate, physiography, geology and soils, and human influences on the landscape are presented. This information provides a useful context for interpreting the condition of Maryland streams.

## 3.1 GEOLOGIC HISTORY

Historical changes in the physical environment are a primary factor influencing the diversity and distribution of aquatic species in Maryland streams. The following discussion describes some events in the past that have influenced, and in many cases continue to influence, Maryland stream ecosystems.

### 3.1.1 Evolution of Drainage Patterns

Chesapeake Bay, the water body into which most Maryland streams drain, has changed dramatically over geologic time. Most streams in the Bay drainage were part of the Susquehanna River tributary network; some areas such as the upper Potomac drained to the west. Approximately 20,000 years ago, glacial activity extended down through New England as far as south-central Pennsylvania. As glacial activity receded, broad-scale landform erosion caused shifts in drainage patterns. Over time, the eastern continental divide shifted considerably westward to its present location between Grantsville and Frostburg, Maryland. As each stream was captured by this shifting continental divide, there were opportunities for interbasin transfers of aquatic species. At present, the species assemblages on both sides of the continental divide overlap considerably, increasing the similarity in community composition between the western and eastern parts of the State.

As a result of glacial and post-glacial landform erosion, there are two major drainages in Maryland today: the Chesapeake Bay which empties into the Atlantic Ocean and the Youghiogheny River, which ultimately drains to the north and to the Mississippi River. All but one of the major river basins in Maryland drain into the Chesapeake Bay (Figure 2-1). Because these basins form natural ecological and aquatic management boundaries, they are the primary reporting units used for the Maryland Biological Stream Survey (MBSS or the Survey).

### 3.1.2 Climatic Changes

Since the time of the last glaciation, a number of climatic events have occurred that have likely influenced the distribution of aquatic biota. These include extended droughts (dry periods covering several decades) in the 13$^{th}$ and 16$^{th}$ centuries, a uniquely cold and cloudy summer in the 1800s, and several unusually wet periods. The fauna that persists today is well adapted to this relatively dynamic environment.

More recently, events such as Hurricane Agnes in 1972 (CRC 1976) and a large snow/rain event in January 1996 have strongly influenced biological, chemical, and physical conditions in Maryland (MDNR, unpublished data) and neighboring Pennsylvania (Hoopes 1975). It is important that MBSS and other data be interpreted in the context of such past abiotic conditions, even if the conditions only persist for weeks or days.

## 3.2 CLIMATE

### 3.2.1 Precipitation

Because all flow in Maryland streams ultimately arises from precipitation, it is an important factor in stream condition. In Maryland, annual precipitation varies geographically, averaging between 40 and 50 inches (Figure 3-1). In the western half of the State, the prevailing winds are from the west, typically mixing moisture from the south with colder temperatures from the north. Because of the prevailing winds and mountain ridges, which create a rainshadow effect, rain and snowfall is greater in the west and precipitation tends to be heavier on west-facing slopes. In the eastern half of the State, prevailing winds are also westerly but many storm events are also influenced by moisture from the coast; precipitation patterns reflect that influence. These precipitation patterns have an obvious effect on runoff (Figure 3-1), a primary factor in determining stream characteristics. Because the flow of water (stream discharge) is one of the critical determinants of stream habitat quantity and quality, drier portions of the

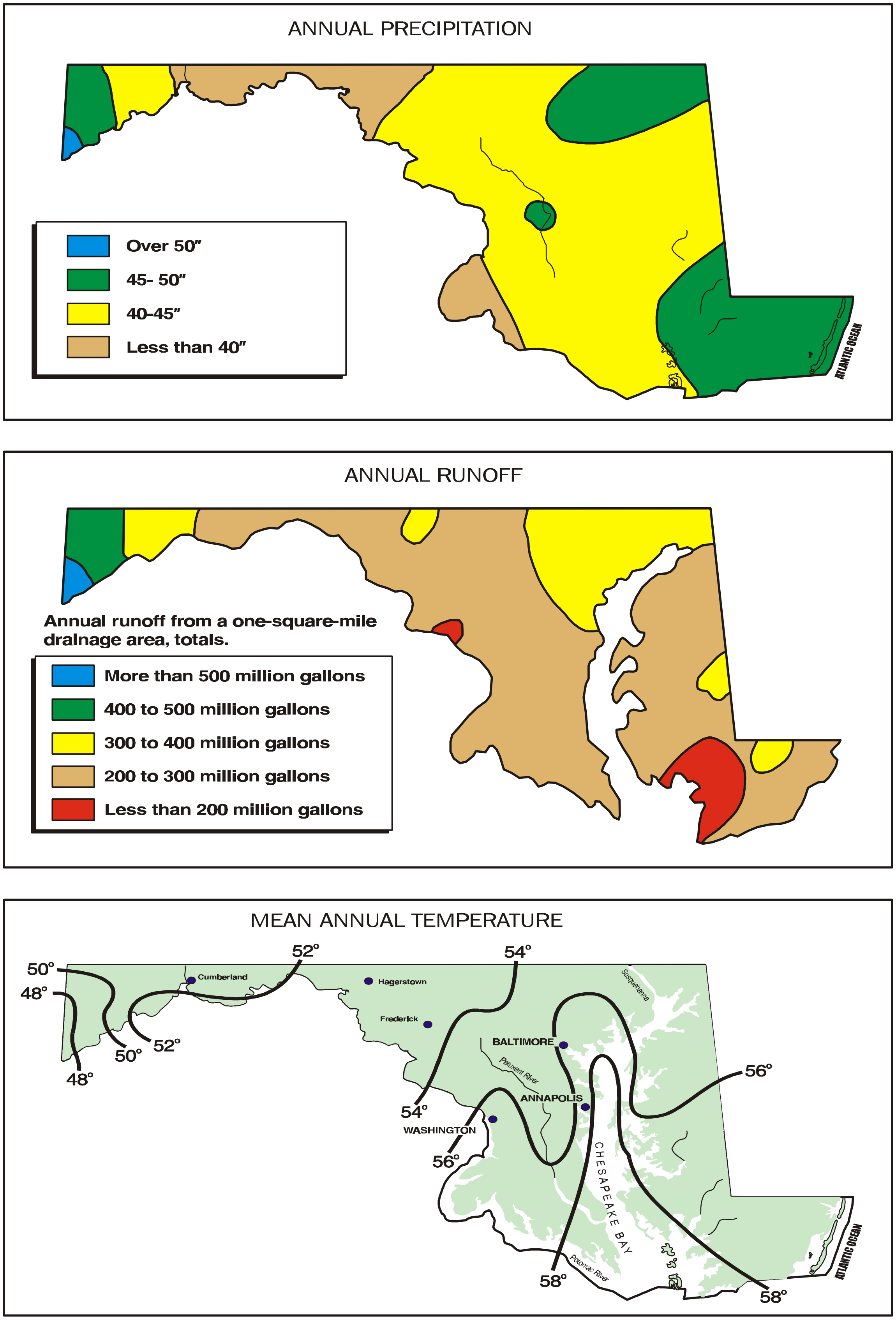



Figure 3-1. Precipitation isobar, annual runoff per square mile of watershed area, and mean annual temperature isobar maps for Maryland (Adapted from Walker 1970)

State should, in general, have less aquatic habitat than areas that are wetter.

### 3.2.2 Temperature

Mean annual temperatures in Maryland vary between 48° and 58°F, with the coldest areas in far western Maryland and warmest areas near the Chesapeake Bay mainstem (Figure 3-1). Maryland is situated between 37° and 39° north latitude and 75° and 79° west longitude; the State is bounded to the east by the Atlantic Ocean and to the west by the Allegheny mountains. The presence of the Atlantic Ocean on the east and the bays and estuaries that line the Chesapeake Bay to its west create an "oceanic" or "insular" climate on the Eastern Shore. This region of the State experiences milder winters and hotter summers than other regions.

The air temperature regime for each region of Maryland has a direct influence on stream water temperatures, generally favoring warmwater fauna in streams of the eastern and southern part of the State, and coldwater fauna to the north and west. The temperature regime can have a dramatic effect on the diversity of its aquatic assemblages. For example, Atlantic coastal states north of Maryland have fewer, but similar numbers of freshwater fish species, while neighboring Virginia supports more than twice as many native fish species (Jenkins and Burkhead 1993). It appears that Maryland's post-glacial temperature regime may have been slightly colder than the threshold for many of Virginia's fishes. Such differences in temperature requirements demonstrate the need to examine local as well as regional expectations for biological communities. This is particularly important in areas where temperatures are marginally acceptable for coldwater communities, because minor watershed disturbances may dramatically alter these communities.

## 3.3 PHYSIOGRAPHY

Maryland extends across five Physiographic Provinces which parallel the Atlantic Coast from New England south to the Gulf of Mexico. From east to west, these provinces are: the Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateau (Figure 3-2). Each of these provinces has characteristics that strongly influence its constituent streams.

### 3.3.1 Coastal Plain

The Coastal Plain is the most extensive of the Physiographic Provinces in Maryland. It ranges in elevation from 0 to more than 100 meters above sea level; the Eastern Shore is relatively flat while the Western Shore is typically rolling upland with higher elevations. In comparison with the predominantly slow-moving streams on the Eastern Shore, Western Shore streams have slightly higher stream gradients and more deeply incised stream channels. One major difference between the Coastal Plain and the other Physiographic Provinces in Maryland is the response of streams to organic enrichment. Because of the lower gradient and naturally limited capacity to mechanically aerate the water and replace oxygen lost via biochemical oxygen demand (BOD), streams in the Coastal Plain more often tend to become more overenriched than elsewhere in the State.

### 3.3.2 Fall Line

The western boundary of the Coastal Plain is the "Fall Line", a sinuous, rather poorly defined "line" characterized by the presence of rapids and waterfalls that mark the beginning of the Piedmont Province. One major waterfall and natural migration barrier to many aquatic species is Great Falls on the Potomac River. The drop in elevation at Great Falls is approximately 10-15 meters, a height that most fish cannot climb except during periods of extreme flooding.

The coincidence of Coastal Plain and Piedmont habitats in the vicinity of the Fall Line tends to result in a mixing of aquatic biota. This mixing typically results in a higher diversity of biota in the transition zone than in upstream or downstream communities. This effect should be considered when interpreting data for the Fall Line region.

### 3.3.3 Piedmont

The Piedmont Province comprises 29 percent of the land area of the State and extends from its eastern limit at the Fall Line to the slopes of Catoctin Mountain, where it borders the Blue Ridge Province. The Piedmont is characterized by rolling terrain and rather deeply incised stream valleys. Streams in this province generally have moderate slopes controlled by bedrock outcrops; however

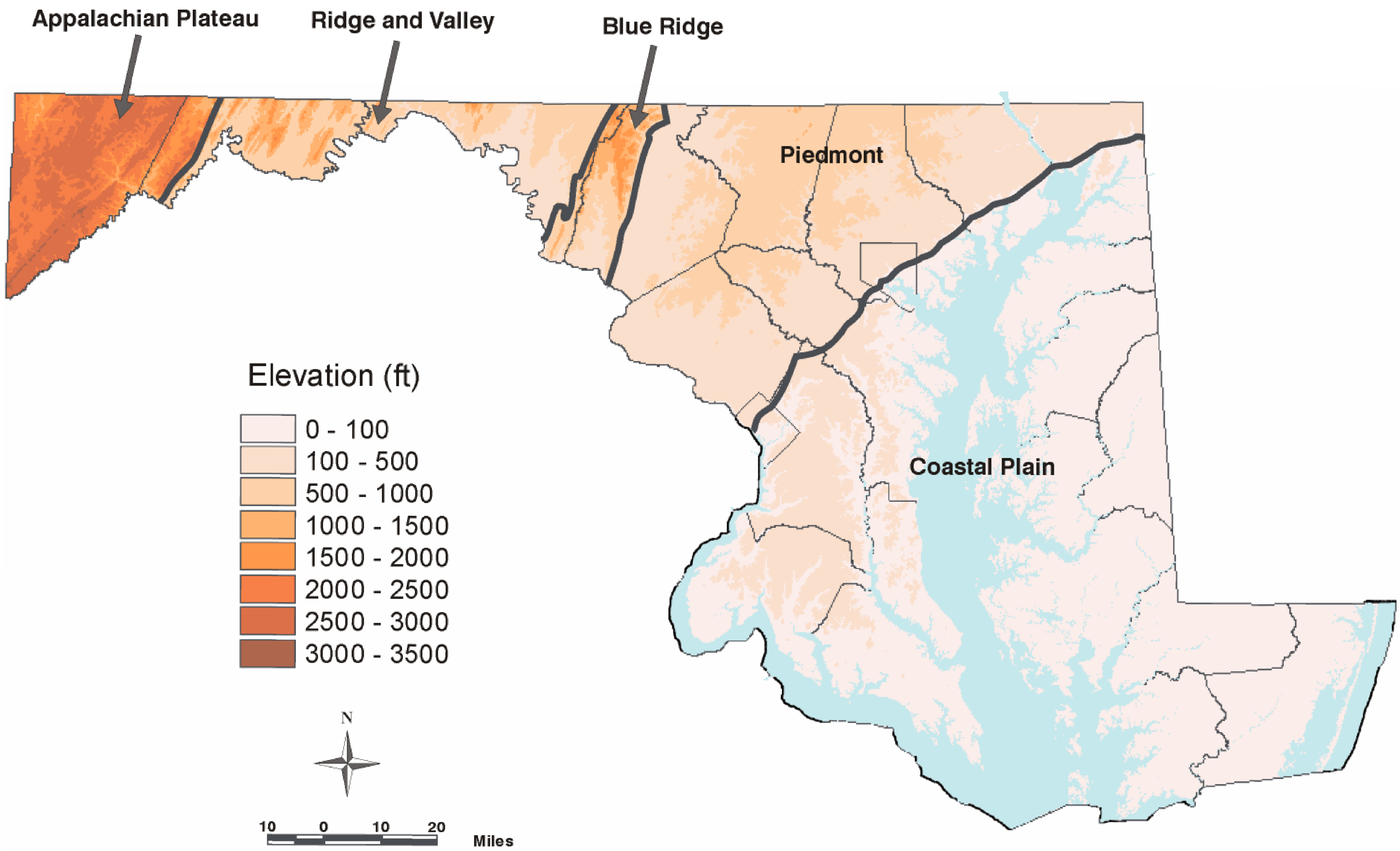



Figure 3-2. Surface elevation map of Maryland (Adapted from MGS 1996)

steeply sloped areas and waterfalls are not uncommon. The variety of rock types, differences in resistence to erosion, and the inherent complexity of physical structure provide this region with a highly diverse topography over elevations from 30 to 300 meters. Like the Coastal Plain, the Piedmont is subdivided into an eastern and western region, defined by streams flowing directly into the Chesapeake Bay and those that flow into the Potomac River, respectively.

### 3.3.4 Blue Ridge

The Blue Ridge Province makes up approximately 5 percent of the area of the State and extends from Catoctin Mountain to South Mountain, with a broad valley floor flanked by the steeper slopes of Catoctin and South Mountains. Elevations in the Blue Ridge range from approximately 30 to 450 meters; stream gradients range from steep on the mountain slopes to moderate in the valleys.

### 3.3.5 Valley and Ridge

The Valley and Ridge Province is located between South Mountain and Dans Mountain in western Allegany County. It comprises about 12 percent of the State and includes the Great Valley in the east and the Western Ridges in the west. The Great Valley is a broad lowland that averages 150 to 180 meters in elevation, rising gradually from the Potomac River toward the Pennsylvania border. The Western Ridges consist of numerous northeasterly aligned ridges. Streams within the valleys are moderately sloped and sinuous, while streams that drain the ridges are often steeply sloped. In total the range in elevation in this province extends from 60 to 600 meters.

### 3.3.6 Appalachian Plateau

The Appalachian Plateau is a broad upland region that extends from Dans Mountain in western Allegany County through the Maryland-West Virginia border. Elevation in the Appalachian Plateau generally ranges from 600 to over 900 meters; stream gradients range from steep along ridges to gentle in some valleys.

## 3.4 GEOLOGY AND SOILS

### 3.4.1 Geology

Geology plays a key role in determining the water chemistry, flow characteristics, and physical structure of Maryland streams. Using the lithogeochemical classification system developed by the USGS (Peper et al. 1999), the rock types found in Maryland fall into one of four classes: carbonate, mafic, resistate, and carbonaceous-sulfidic (Figure 3- 3). Each of these classes influences streams in different ways.

Carbonate rocks are found in narrow bands in western Maryland, occur extensively in central Maryland, and are absent from the Coastal Plain. These rocks provide abundant calcium which tends to increase biological productivity and buffers the effects of acidity from sources such as acidic deposition. Streams flowing through carbonate rock formations tend to be well-oxygenated and may have high nitrate levels in agricultural areas. Groundwater in carbonate rocks occupies channels and cavities that are usually small, but may be very large. Movement of groundwater is usually rapid and springs are common and frequently large. The presence of springs in a watershed tends to counter the effects of droughts and spates because they create refugia with relatively constant flows.

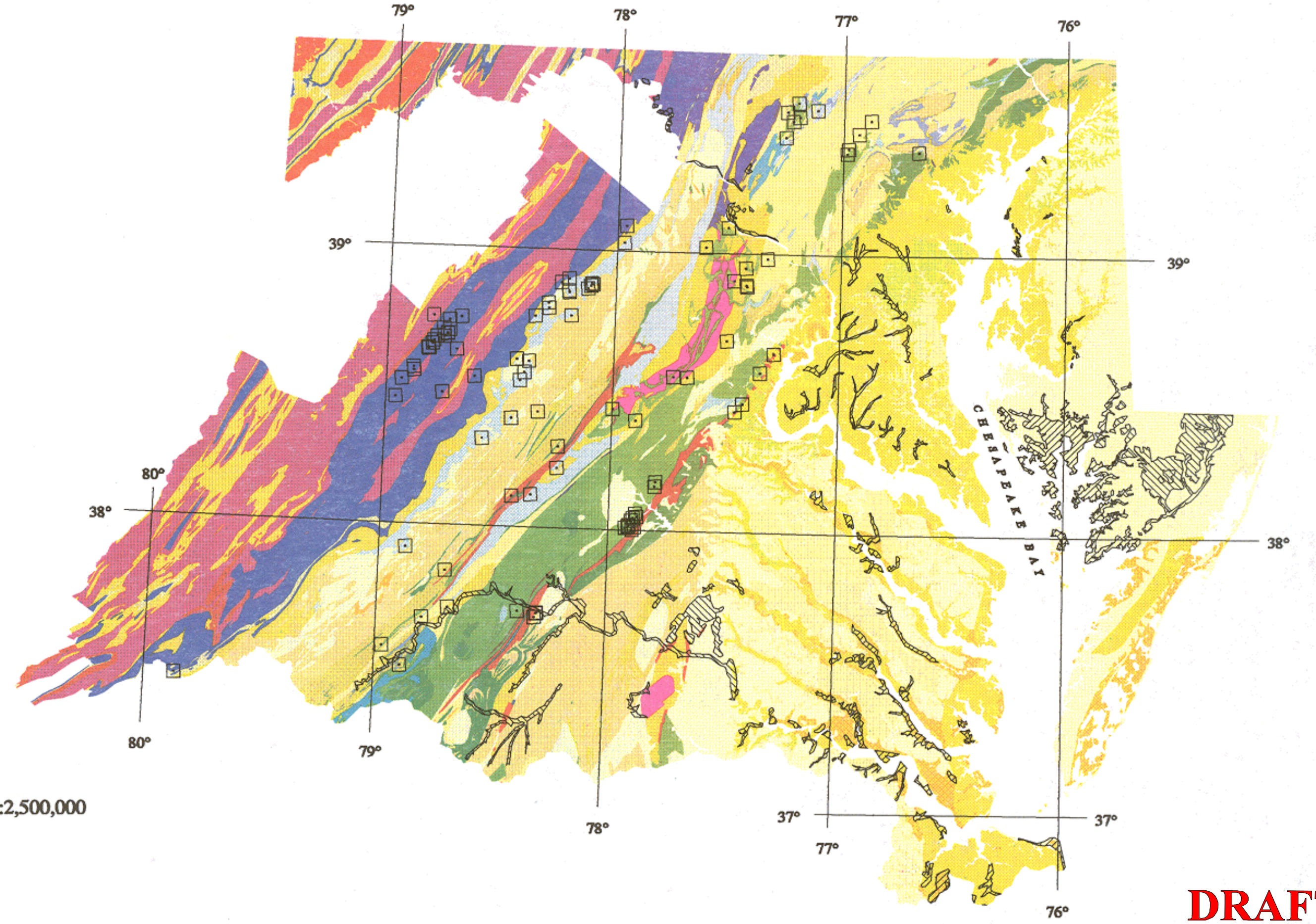
Mafic rocks, which are found along the Fall Line, several isolated areas of the Piedmont, and portions of the northern Coastal Plain, also provide some calcium buffering capacity. Streams flowing through mafic rock formations tend to be neutral to slightly acidic and well-oxygenated, with substrates sub-oxic to reducing in places. Groundwater in mafic rocks occupies small cracks and fissures. Groundwater movement is slow and springs are rare and usually small.

Resistate rocks are found throughout the State, but are especially prevalent in the Piedmont and dominant in the Coastal Plain, and provide little acid-neutralizing capacity. Streams flowing through resistate rock formations tend to be well-oxygenated, but clay-rich rock and sediment is common. Groundwater in resistate rocks occupies small cracks and fissures, moves slowly, and rarely creates springs which are usually small. In the Coastal Plain, groundwater occupies space between particles and movement is slow to moderately rapid.

Carbonaceous-sulfidic rocks, the predominant rock type in the Ridge and Valley and Appalachian Plateau provinces, are associated with historical bog, marsh, or swamp deposits. Streams flowing through this rock formation are reported to be acidic to neutral, to be abundant in dissolved organic carbon and iron, to possess low nitrate levels, and to often have low DO levels. Groundwater in carbonaceous-sulfidic rocks occupies small cracks and fissures, moves slowly, and rarely creates springs which are usually small.

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
VIRGINIA DIVISION OF MINERAL RESOURCES
AND THE
MARYLAND GEOLOGICAL SURVEY

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**PRELIMINARY LITHOGEOCHEMICAL MAP OF NEAR-SURFACE ROCK TYPES IN THE CHESAPEAKE BAY WATERSHED, VIRGINIA AND MARYLAND**

By

John D. Peper, Lucy B. McCartan, J. Wright Horton, Jr., and James E. Reddy

Figure 3-3. Lithogeochemistry map of Maryland (USGS 1999)

## EXPLANATION OF MAP UNITS

### I. SEDIMENTARY ROCKS AND THEIR METAMORPIC EQUIVALENTS

——— Carbonate-rich rocks (acid neutralizing and soluble, forms thin alkaline clay soils)

11: limestone, dolomite, limestone-pebble conglomerate; includes calcareous mudstones

12: marble and some calc-silicate rock

——— Siliciclastic sedimentary rocks (moderately acid-neutralizing (cs) to reducing-acidic (s), bedded and permeable, forms neutral to slightly acid soils)

21cs: calcareous, locally sulfidic, gray mudstone

22: sandstone and interbedded sandstone and conglomerate; minor carbonate cement; may contain mudstone

23s: carbonaceous, graphitic, or sulfidic slate and shale

24s: coal beds and zones containing abundant coal beds

——— Metamorphosed clastic sedimentary rocks; includes some metavolcanic layers (moderately acid-neutralizing (c) to acidic (s), recrystallized and foliated, forms neutral to slightly acid soils)

31s: graphitic and sulfidic slate; includes some metagraywacke

32: pelitic schist and phyllite; locally quartzofeldspathic

32s: sulfidic schist and minor quartzofeldspathic schist

32c: calcareous schist and gneiss

33: metasandstone, quartzite, quartz granofels, and gneiss; locally schistose

34: coarse-grained felsic gneiss locally contains schist and amphibolite; typically enriched in granitic components like unit 61

### II. IGNEOUS ROCKS AND THEIR METAMORPHIC EQUIVALENTS

——— Mafic igneous rocks and their metamorphic equivalents (moderately acid-neutralizing, massive, has interlocking grains, forms smectitic clay soils)

41c: greenstone, greenschist facies metabasalt, schistose metamorphosed mafic rocks with dispersed carbonate

41: hornblende-plagioclase amphibolite

42: mafic volcanic rocks mixed with lesser felsic volcanics and clastic rocks; metadiamictite, schist-matrix melange

43: massive, mafic plutonic rocks; includes diorite, gabbro, monzodiorite, diabase, and basalt

——— Ultramafic rocks

50c: metamorphosed ultramafic rocks; includes ultramafic melanges, serpentinite, tremolite-talc schist; includes minor carbonate soils

Figure 3-3. Cont'd

## EXPLANATION OF MAP UNITS

-------- Felsic igneous rocks and their metamorphic equivalents (forms neutral to moderately acidic, sandy soils)

61: granitoid plutonic rocks; includes granite, quartz monzonite, granodiorite, tonalite, trondhjemite, and equivalent gneiss

61v: fine-grained felsic rocks (volcanic and shallow plutonic); cryptocrystalline to very fine-grained

62: quartz-poor plutonic rocks, includes syenite, quartz-syenite, nepheline syenite, and monzonite

III. UNCONSOLIDATED SEDIMENTS (primary porosity is high)

73: mud and clay (>15% clay and silt size particles)

74: quartz silt, sand, and gravel; weathered residuum from which iron and carbonate have been removed

75: organic-rich deposits, including peat

76: mixtures of 73, 74, 75

-------- Iron-rich sediment

77: greensand, silty in places; magnetite and ferroilmenite beach sand; bog iron ore

CARBON-RICH SOILS (From U.S. Department of Agriculture, 1994)

11,000 - 17,199 g/square meter total soil carbon

> 17,199 g/square meter total soil carbon

MINERAL DEPOSIT (From USGS, National Mineral Resource Database)

sulfide deposit

Figure 3-3. Cont'd

### 3.4.2 Soils

Soils play a key role in the formation and maintenance of stream channels. In areas of high soil erodibility, the effects of watershed disturbance (such as loss of riparian buffers) are usually more pronounced. In Maryland, most soils have high or moderately high erodibility (Figure 3-4). In the western half of the State, erodibility is relatively comparable among watersheds. In contrast, erodibility is highly variable in the eastern portion of the State, potentially producing differences in degradation from the same degree of watershed perturbation.

## 3.5 HUMAN INFLUENCES

The influence of human activities extends to every stream and watershed in Maryland. Because virtually no pre-European records of Maryland streams exist and few more modern records survive, statements about ecological status must be made largely in the context of present day conditions. In this section, we present an overview of historical and present human influence on Maryland's streams and watersheds.

### 3.5.1 Forests and Forest Practices

In 1634, when Lord Calvert first arrived in Maryland, the State was nearly 95% forested (Besley 1916). Today, forests occupy only about 44% of the land area of Maryland, with the largest blocks of contiguous forest in western Maryland (Figure 3-5). More dramatic is the fact that only about 80 acres of old growth (not previously logged) forest exists today; this includes a 40 acre stand of eastern hemlock along a steep slope adjoining the Youghiogheny River and a 40 acre mixed hardwood stand in Belt Woods near the town of Bowie.

Even where forests have regrown, many are managed for timber production, causing more subtle but still substantial adverse effects on streams. The negative effects of many logging practices on stream water quality, temperature, erosion rates, evapotranspiration, and hydrology are well documented in the scientific literature (Hunter 1990, Murphy 1995); the loss of wood naturally falling into stream channels, however, has not been well documented (Masser and Sedell 1994). Both historical and modern forestry management has viewed the senescence and death of trees as wasteful and potentially harmful to forest health. For these reasons, forest practices rarely allow any large woody debris to enter streams. As a result, virtually no stream in Maryland has the abundance of large woody debris that likely existed before European settlement. Because wood in streams creates important habitat for organisms, alters channel morphology and bank erosion rates, and helps sequester or delay the downstream passage of nutrients, the loss of woody debris has been and continues to be a major influence on stream condition in Maryland.

### 3.5.2 Agriculture and Urbanization

Early settlers were drawn to Maryland by its diverse natural resources. The region provided favorable soils, topography, and climate for agriculture (especially tobacco), as well as natural harbors and waterways to facilitate the transport of goods, services, and people. By the early 1700s, European settlement was extensive, and an elaborate system of ditches was created to drain wetlands for agricultural use. The burgeoning economy led to the development of more urban centers and by 1776 the cities of Annapolis, Baltimore, Frederick, and Hagerstown had been established. Water-borne diseases, including malaria, yellow fever, and cholera were prominent in urban areas where raw sewage accumulated in open ditches and contaminated waterways. In addition to human health hazards, the quality of the region's rivers and bays deteriorated. Deforestation hastened erosion and increased sedimentation of the Bay's tributaries. Several tobacco ports, including Joppatowne, Port Tobacco, and Upper Marlboro were closed as channels filled with sediment and became unnavigable. It should be noted that each ton of sediment from overland runoff can destabilize stream channels and generate many more tons of sediment from increased streambank erosion (Rosgen 1996).

The 19$^{th}$ and early 20$^{th}$ centuries wrought numerous other changes to stream resources. With the advent of larger farm machinery during the Industrial Revolution, hedgerows and stream buffers were removed to increase efficiency and productivity. As a result, surface runoff and sediment loading to streams increased and stream conditions further deteriorated. This long history of exploiting the land left an imprint of the character of streams even after the 1960s, when soil erosion control practices on agricultural and urban lands first began reducing the amount of sediment entering into Maryland streams.

Agriculture has also had an effect on water chemistry in Maryland streams. As the agriculture industry grew and matured, increasing amounts of nutrients were added to fields to boost productivity. Today, nitrogen concentrations in streams are elevated in most areas of the State and phosphorous concentrations are high near large poultry and

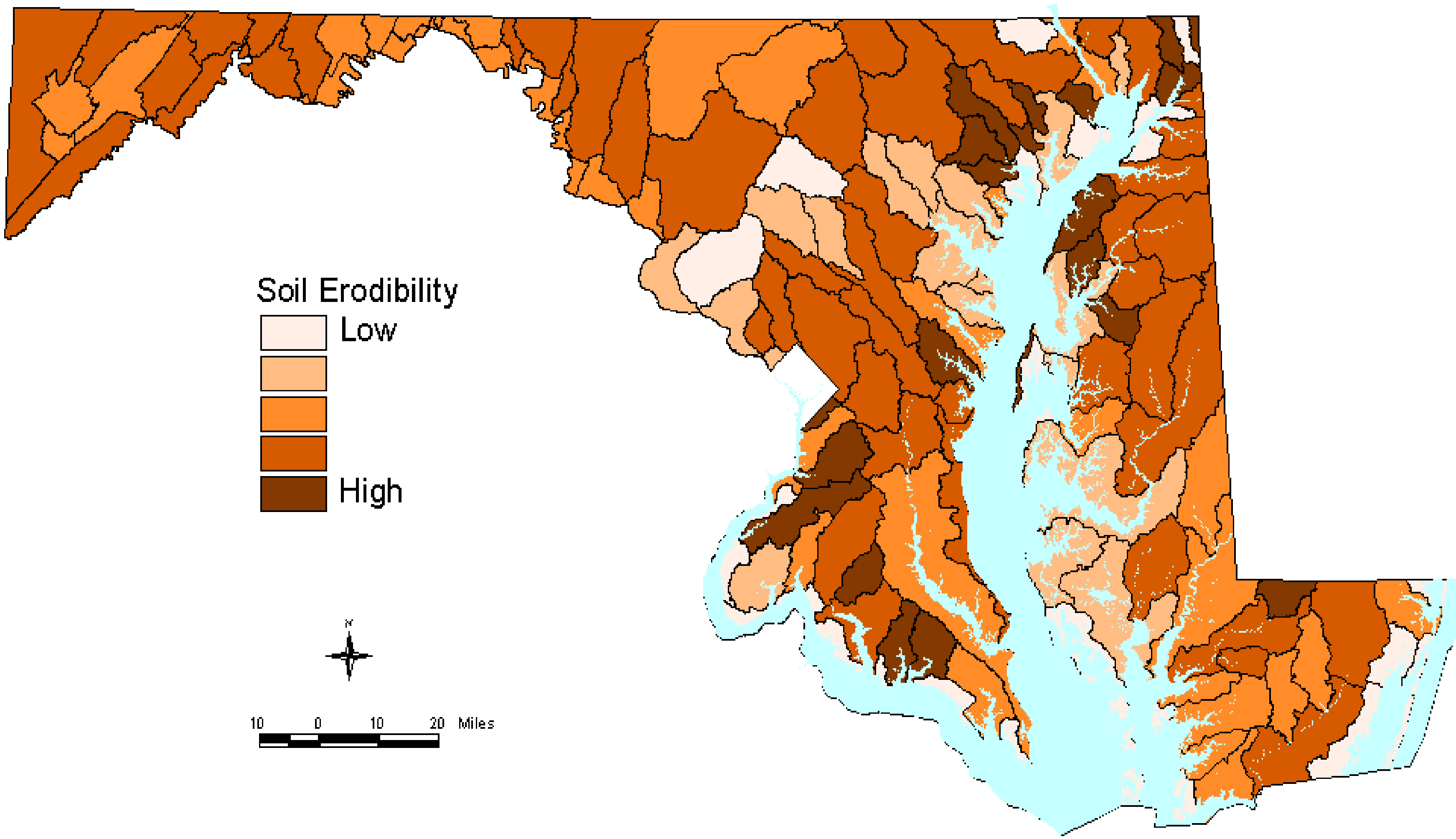


Figure 3-4. Soil erodibility map of Maryland (MDNR, Watershed Management and Analysis Division)

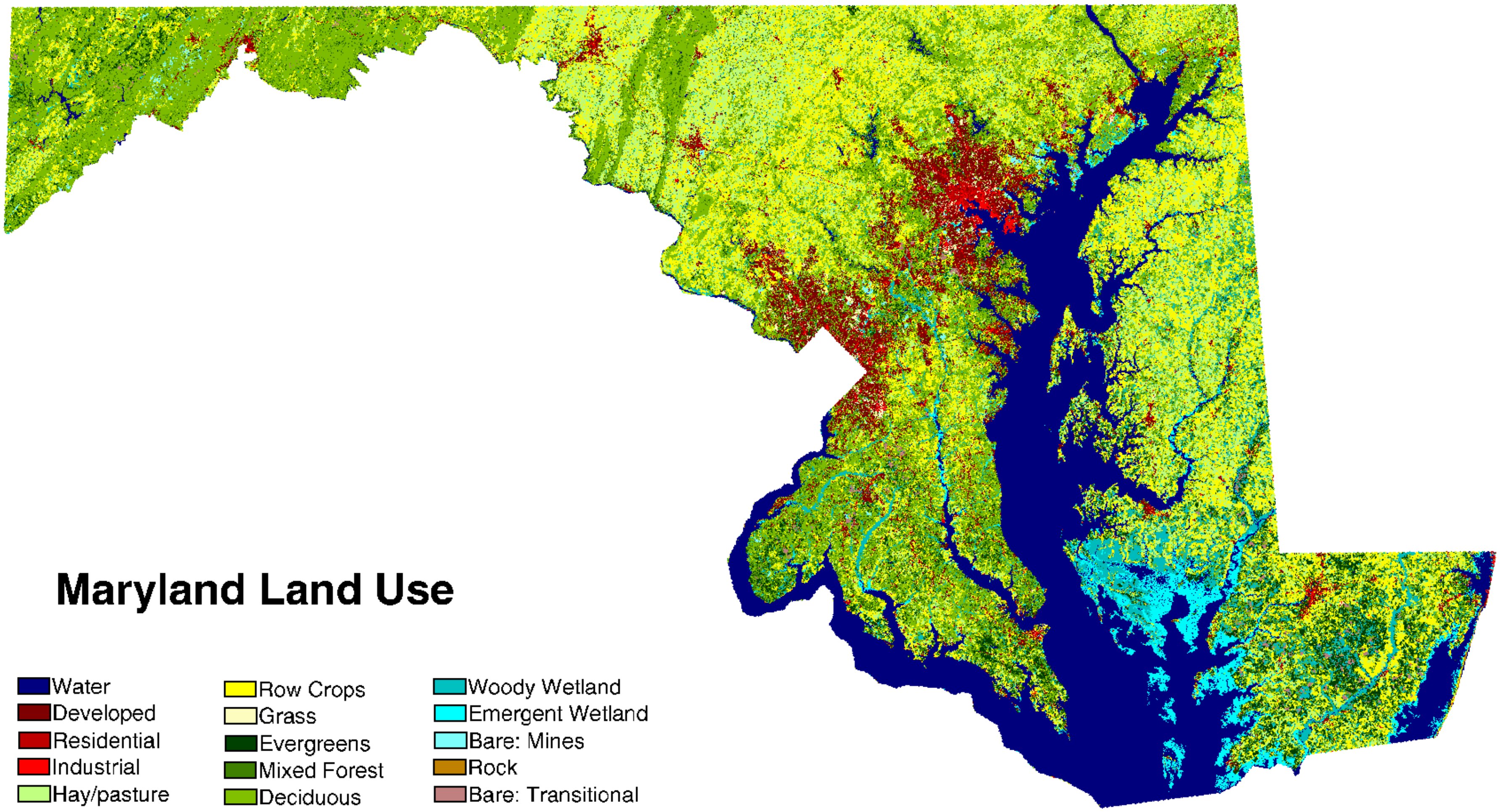


Figure 3-5. Land use map of Maryland (Multi-Resolution Land Characteristics data)

hog production operations. In addition, limestone is routinely applied to cropland, especially on the calcium-poor Coastal Plain. The addition of nutrients and limestone has affected the metabolism and productivity of many of Maryland's streams; in many cases, it has altered the biological community as well. For example, the addition of buffering capacity via limestone applications on the Coastal Plain has probably reduced the populations of acid-tolerant endemic species (as they are out-competed by acid-sensitive invaders).

After World War II, a new type of development, suburbs, arose on the outskirts of cities in Maryland and elsewhere as citizens sought to escape from the urban lifestyle. Over time, agricultural and forested lands adjacent to cities were converted to suburban housing and industries, creating more and more impervious surfaces. This development was accompanied by a network of roads (Figure 3-6). Although road density is highest in the Baltimore-Washington corridor, there are essentially no roadless watersheds in Maryland. In addition to providing a conduit for rapid stormwater runoff into streams, many roads also alter channel morphology or create barriers to fish migration.

At present, the density of humans in Maryland is about 1.3 people per acre (USCOM 1992) . Population density is greatest around the Baltimore-Washington metropolitan area, and lowest in western Maryland and most portions of the Eastern Shore (Figure 3-7). In general, the higher the human population density, the greater the ecological impacts on streams and stream communities. These impacts include increased dumping of contaminants, increased risk of toxic spills, increased effects of motor vehicle operation, increased likelihood of channelization and piping of streams, and more rapid stormwater runoff.

### 3.5.3 Fur Trade

One of the first impacts to Maryland streams during European colonization was the extirpation of the beaver population from the State. Formerly abundant, beavers altered stream ecosystems by raising water tables, trapping nutrients, altering channel morphology and gradient, creating openings in the forest, and adding woody debris. As beavers were eliminated, stream channels became less sinuous and habitat diversity was reduced. Today, reintroductions and a reduced demand for fur have resulted in a resurgence of beaver in many areas of the State; nonetheless, beaver densities are still well below historical levels.

### 3.5.4 Mining

With the advent of the Industrial Revolution, there was a new demand for raw materials for building and energy in Maryland. Sand, gravel, and rock quarries (many along streams and rivers) sprang up to fill the need; today there are many such facilities across the State. In most cases, the alteration of stream habitats has been relatively localized. However, the mining of coal in the Appalachian Plateau has had a pronounced effect on streams in that region. In 1929, runoff of water used to fight a fire in a gob pile (coal mine tailings) at Crellin, West Virginia, destroyed virtually all life in the Youghiogheny River for as long as 40 years (Powell 1967). In streams of the North Branch of the Potomac River, acid mine drainage (AMD), primarily from abandoned deep mines, has created a legacy of severe impairment in a number of streams as well as the mainstem river. To treat the problem, calcium is being added via automated dosers in several locations; the mitigative effects of mechanical dosers, however, cease when funds to operate them are withdrawn. The impairment associated with AMD includes cementing of substrates, addition of fine sediment, high levels of heavy metals, and low pH.

### 3.5.5 Air Impacts

As the population and industrial base of Maryland and other states in the region has expanded, so too has the use of coal and petroleum products for energy. As a consequence of combustion, nitrogen and sulfur oxides are released into the atmosphere. Because Maryland is situated within the "belt of prevailing westerlies," atmospheric pollution is transported to the State from the Midwest. For example, the Chesapeake Bay airshed is much larger than its watershed and includes parts of twelve states (Figure 3-8). While the deposition of atmospheric contaminants such as acid deposition across Maryland is relatively even (Bartoshesky et al. 1987), the effects on streams vary considerably by physiographic region according to the natural buffering capacity of the soils. The Coastal Plain, portions of the Blue Ridge and Piedmont, and Appalachian Plateau are sensitive to acidic deposition. In contrast, most of the Piedmont, the remaining portions of the Blue Ridge, and Valley and Ridge provinces are well buffered and resistant to acidification.

### 3.5.6 Water Impacts

As the pace of colonization and development of the land in Maryland increased, the streams and rivers of the State were

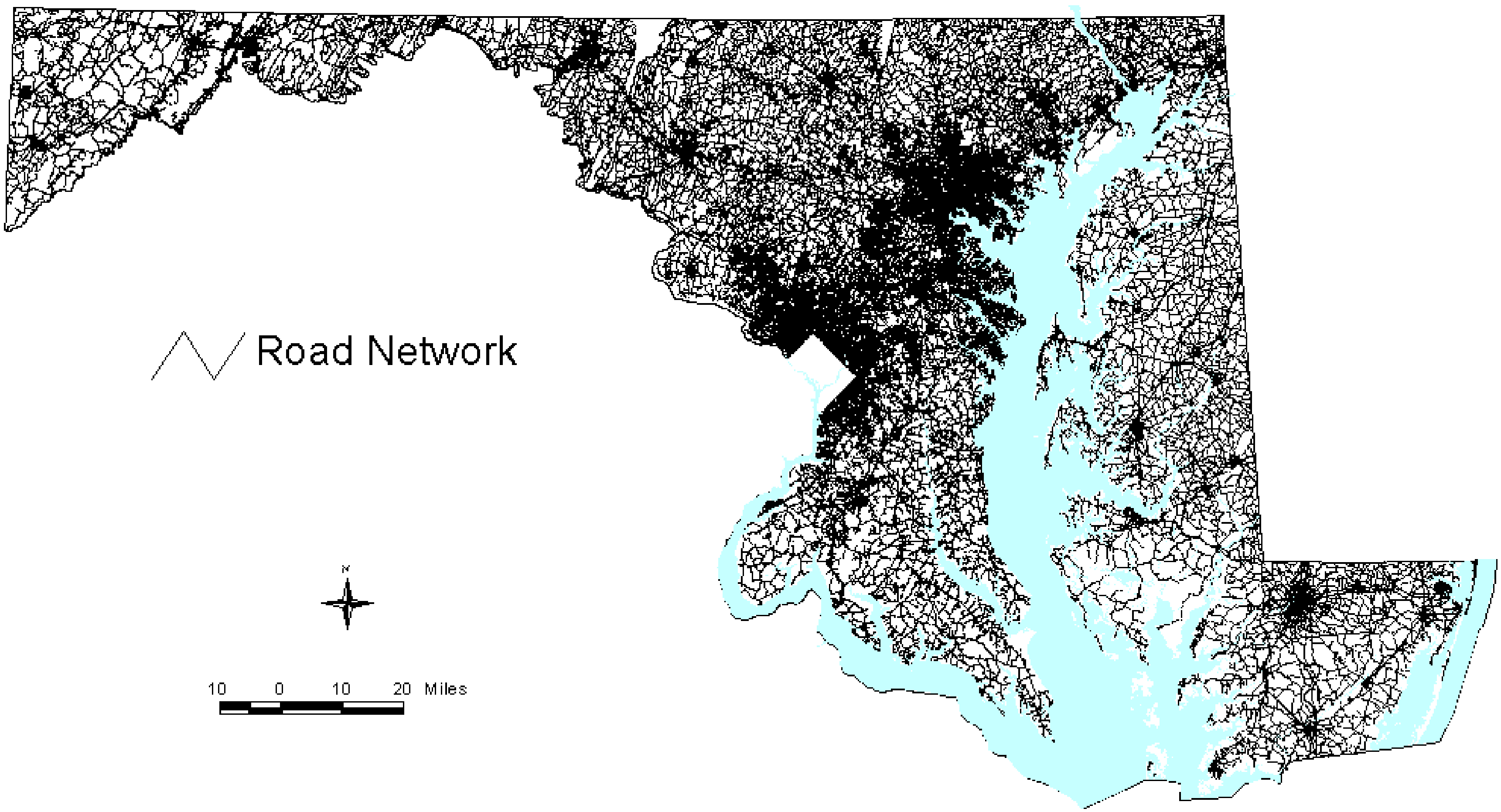


Figure 3-6. Road network map of Maryland (Maryland State Highway Administration)

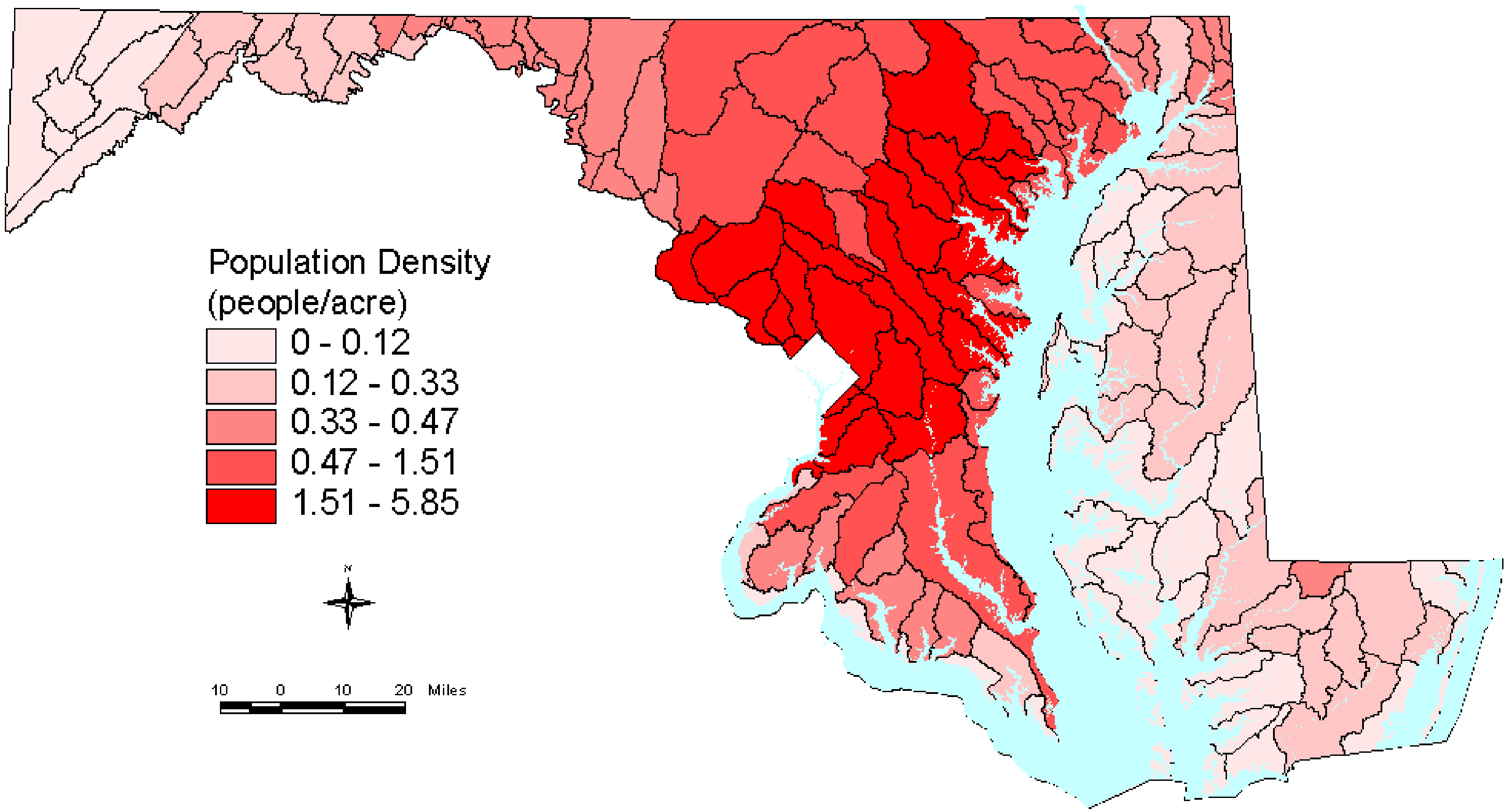


Figure 3-7. Population density map of Maryland based on 1990 census (MDNR, Watershed Management and Analysis Division)

# CHESAPEAKE BAY
# AIRSHED AND WATERSHED

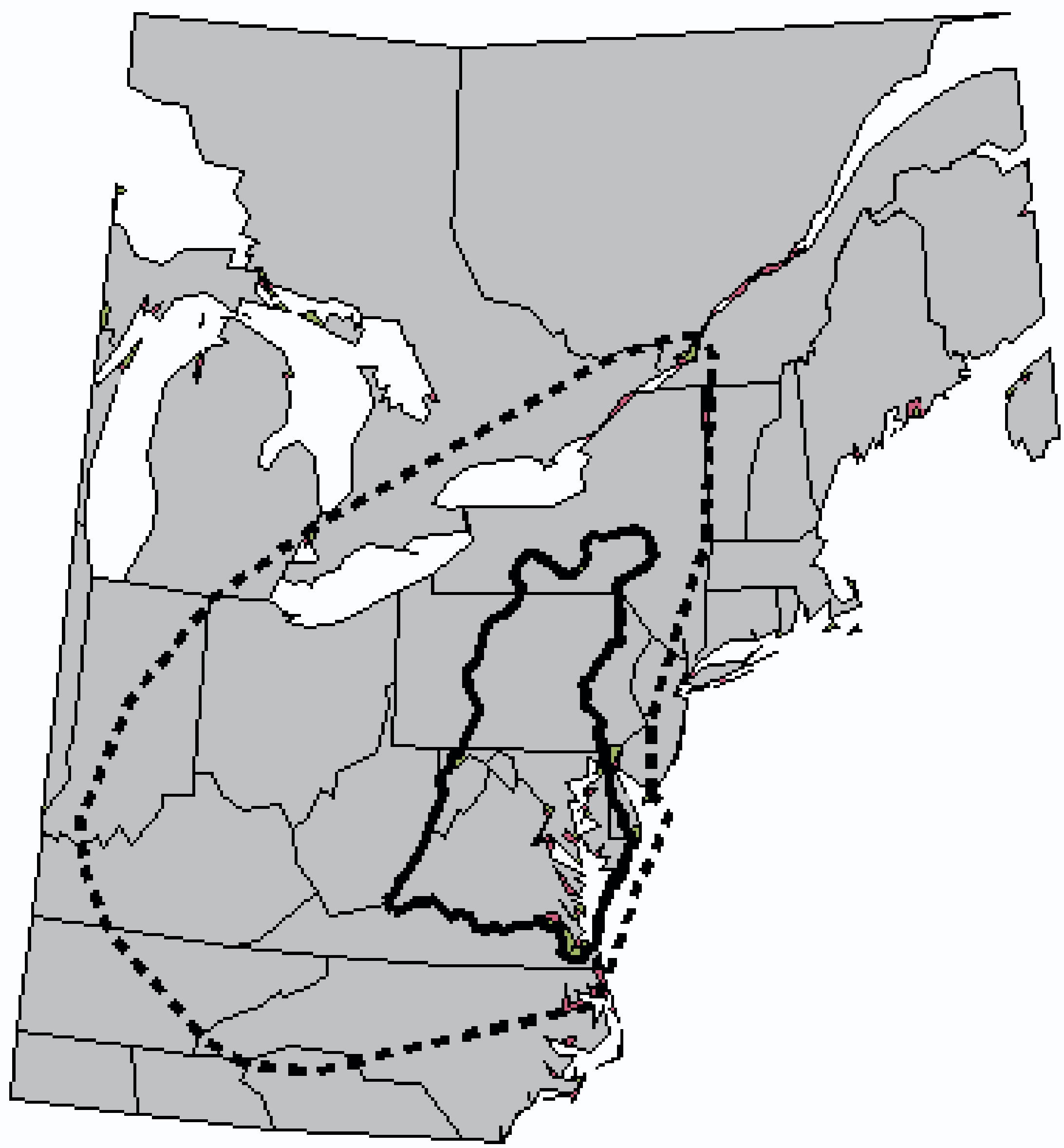

Figure 3-8. Airshed and watershed map for the Chesapeake Bay. Dotted line indicates airshed, solid line indicates watershed.

increasingly utilized for power, drinking water, and other uses. Today, more than 1,000 man-made barriers to fish movement are known to exist in areas potentially used by migratory species; there may be many more barriers in areas above where migration is currently possible (Figure 3-9). These barriers have restricted the abundance and distribution of aquatic species such as the American eel, once a dominant stream fish in many basins of the State. The loss of migratory species from local aquatic communities needs to be considered when developing and applying indicators of biological integrity for streams.

In addition to intentional and unintentional blockages to stream passage, stream channels have been converted into conduits for flood transport in Maryland's urban areas, especially the Baltimore-Washington metropolitan area. Typically, natural streams are transformed into concrete trapezoids to speed the flow of flood waters; these artificial channels provide essentially no useable habitat for aquatic organisms.

With increases in human population density, the consumptive and non-consumptive uses of water have also grown. In many areas of the State, declining well levels indicate that consumption rates may be exceeding recharge rates (USGS 1996), potentially reducing streamflows as well. Many streams have unpermitted water withdrawal systems on them; such water withdrawals during low flow conditions in the summer frequently result in increased water temperatures and less physical habitat available to organisms. In addition, higher levels of imperviousness in Maryland's watersheds have reduced groundwater recharge via infiltration. This phenomenon is especially pronounced in urban areas and often results in substantial reductions in habitat quantity and quality.

### 3.5.7 Summary of Human Influences

As described above, stream conditions in Maryland have been greatly influenced by both natural and human-induced changes to the environment. In addition to accounting for the natural variation among regional and local settings, an accurate assessment of Maryland streams needs to consider that even areas with little human activity today may have been dramatically influenced by historical impacts. Indeed, because of diffuse effects such as acidic deposition, no truly pristine streams exist in Maryland today. The fact that all the landscapes in the State have been modified from their natural condition should be kept in mind when evaluating data in this report; it is especially important when assessing stream condition using reference-based indicators. The history of human influences on Maryland streams sets obvious limits on the number of high quality streams that can be preserved and the level of integrity to which they can be restored. Therefore, it is critical that natural resource managers develop an appropriate vision of desired conditions for Maryland streams and view the results of the Survey in that context.

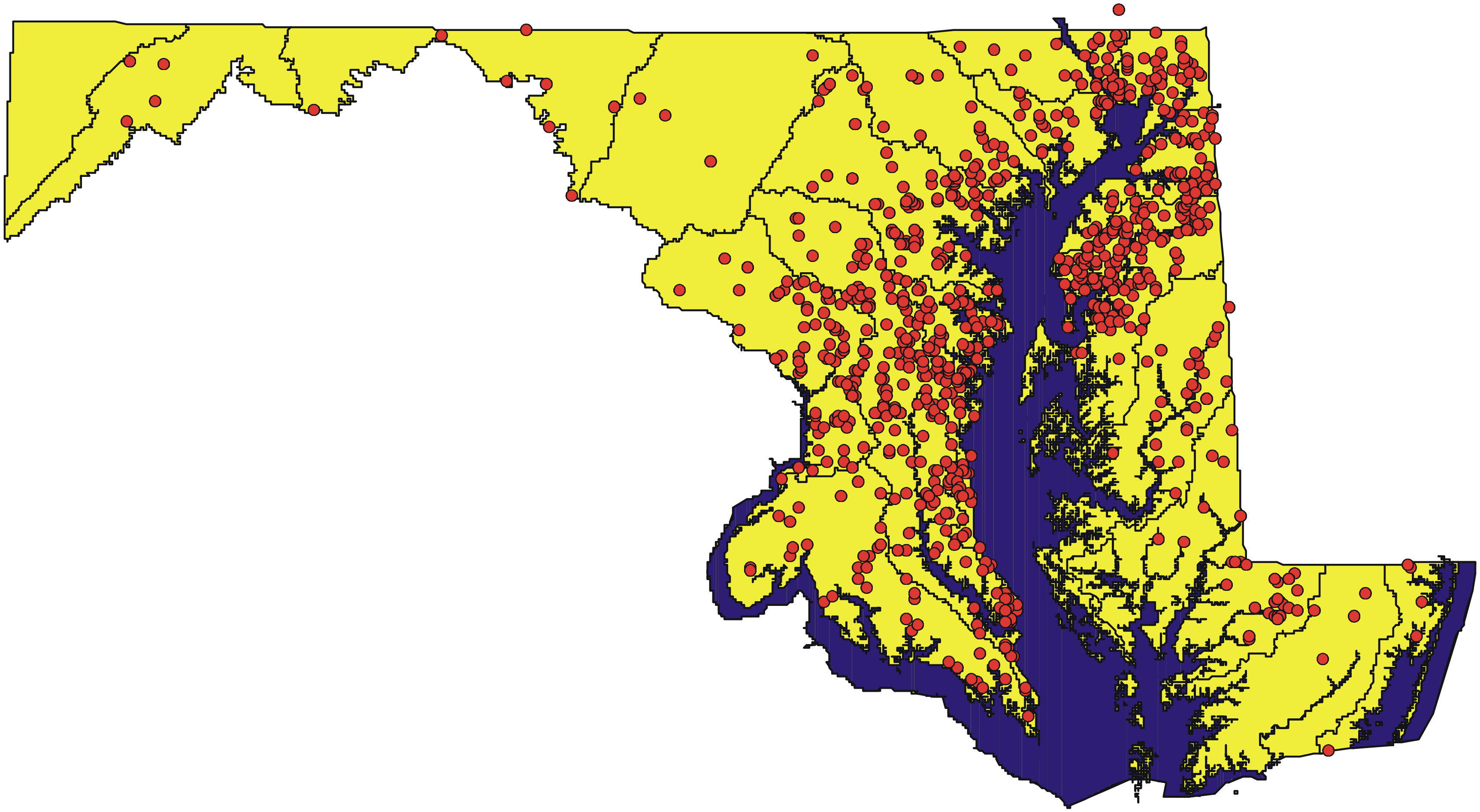

Figure 3-9. Map of dams and other barriers to fish migration in Maryland (Maryland Department of Natural Resources Fisheries Service, unpublished data)